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ECONOMIC IMPORTANCE OF RED ROT AND COMPARATIVE SUSCEPTIBILITY OF SOME SUGARCANE VARIETIES IN THE SOUTHERN UNITED STATES

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INTRODUCTION

Red rot, caused by *Colletotrichum falcatum* Went, has been a source of loss to the sugarcane industry in the southern part of the United States for many years, particularly in the "sugar bowl" of southern Louisiana, where it is annually responsible for reduced stands of cane, stubble deterioration, and poor quality of juice in susceptible varieties. In the sirup-producing sections of Mississippi, Alabama, Georgia, and Florida, where spring planting of cane is the rule, its principal damage is to banked seed cane, necessitating the banking of considerably larger quantities of cane than are actually needed for planting in order to insure an adequate supply. Even then, poor stands often result when susceptible varieties are grown. In southern Florida, with a climate essentially tropical in nature, red rot is of little or no importance in seed rotting because winter temperatures do not, as a rule, go low enough to seriously retard the germination of fall-planted cane or hinder immediate sprouting of stubbles after harvesting of the previous crop. However, the disease may attack standing cane of susceptible varieties, particularly in conjunction with stalk borers, and cause important reductions of recoverable sugar in the factory. Even in the absence of borer injury serious losses to susceptible varieties may result from infection through the nodes, such as have occurred in P. O. J. 2714 in recent years.

Red rot in seed cuttings, the short upright stubble rhizomes, and standing cane may be recognized, on splitting the stalk, by a longitudinal reddening of the normally white or yellowish-white internal tissues of the internode, especially when this red color is interrupted by occasional white patches extending crosswise of the stalk. Figure 1 shows typical internal variation in color and irregularly zoned patches of grayish white in two diseased stalks contrasted with a healthy cane of the very susceptible P. O. J. 213 variety. Unless these whitish patches are present, identification as red rot is often uncertain without microscopic examination or culture of the causative fungus. Almost any sort of wounding, including attack by other disease organ-

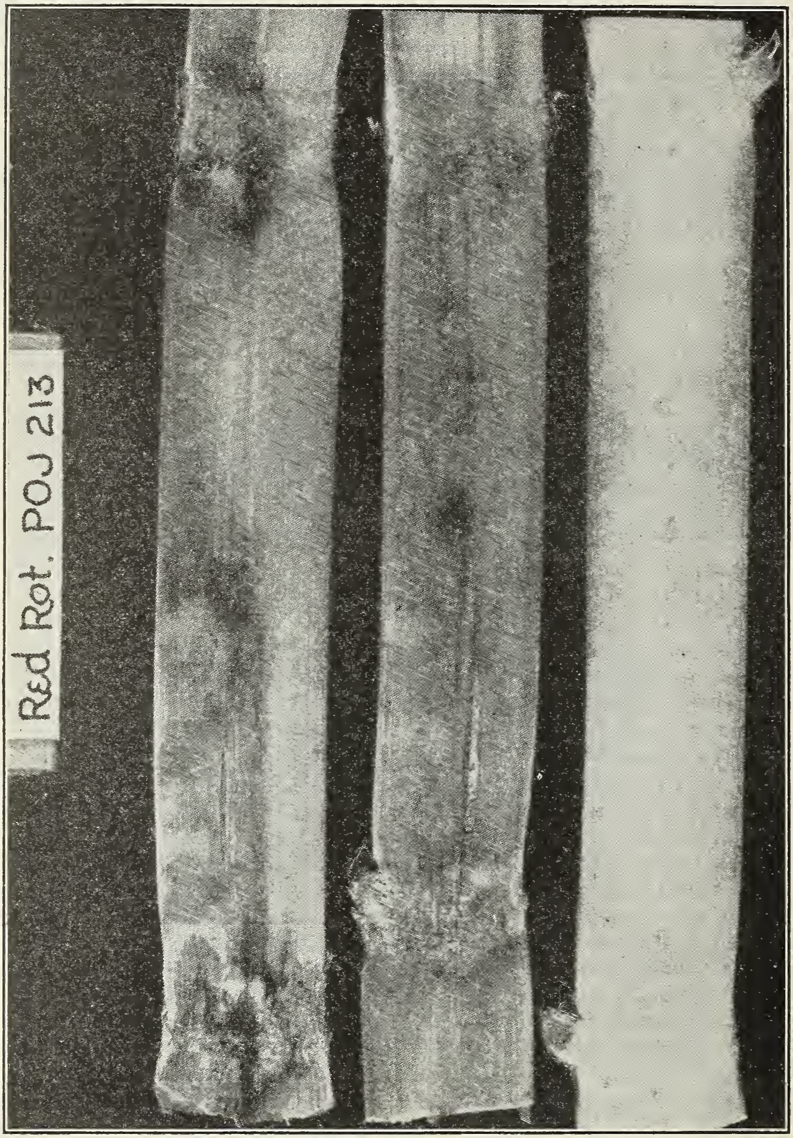

FIGURE 1.—Typical internal stalk symptoms of the red rot of sugarcane of the very susceptible P. O. J. 213 variety, showing whitish patches extending across the rotted areas and matted mycelium in the pith cavity in 1 of the 2 diseased stalks, contrasted with the natural color of a healthy stalk.

isms and stalk borers, causes a red color in the adjoining tissues which represents the natural reaction of the cane plant. However, this wound reaction is usually limited to the immediate borders of the injury; but when red rot is present, starting for example from borer holes, the red color (depending upon resistance of the variety) precedes or follows the invasion of the fungus and may extend through many joints of the stalk rendering it worthless for planting or milling purposes. Canes of susceptible varieties recently damaged by borers may show but little red rot at planting time, but subsequent enforced dormancy during the winter months permits the disease to spread rapidly through the stalks and causes germination and stand failure. Even borer-free stalks of very susceptible varieties, such as P. O. J. 213, may likewise fail to give a stand because of infection directly through the uninjured root bands.

The presence of red rot in the United States was first reported in 1910 by Edgerton (*9*) [1] in Louisiana, and soon thereafter was found in Georgia and Florida. The date and origin of its introduction into the United States are not known, but considering its rather wide distribution in Louisiana in 1911 (*10*) and its presence in other Southern States at that time, it seems probable that it had been present there for several years prior to its discovery. The exact extent of losses from the disease through the ensuing years would be impossible to estimate accurately, but from a perusal of articles and reports by both scientific and plantation men over a period of some 20 years, it is evident that red rot has been to some degree a constant source of loss to the industry.

WIDESPREAD FAILURE OF P. O. J. 213

Red rot became a very serious problem in Louisiana in 1930 as a result of the widespread failure of P. O. J. 213. This variety had become the leading commercial cane of the State following the abandonment of Purple, Ribbon, and D–74 several years previously because of severe injury by mosaic. The sudden decline of this very widely cultivated cane under conditions where it had formerly thrived has been a source of much concern to those connected with the industry, and has served to focus attention not only on the question of securing more disease-resistant canes but on seeking the underlying causes of such failure in order that a similar situation might be avoided in the future.

That P. O. J. 213 was generally believed to be resistant to red rot at the time of its release for commercial cultivation may be assumed from the absence of reports of any damage to it from the disease (which certainly would have been made had it shown any indication of the extreme injury of later years), and seems further evident from Edgerton's statements that "to the red rot disease, P. O. J. 213 is highly resistant, though not immune" (*12*), and "234 and 213 (P. O. J.) are very resistant to this disease (red rot)" (*1*).

The experience of 1930 with P. O. J. 213 has been repeated to some degree in every succeeding season, with the result that its cultivation has declined to the point where it is no longer a major variety in the State. Figure 2 shows typical stand failures of plant cane of this variety experienced for the 1931 and 1933 crops in many parts of the sugar district.

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[1] Italic numbers in parentheses refer to Literature Cited, p. 26.

When a variety of cane, which has become well established and successfully cultivated in a certain district over a period of several years, suddenly declines to the point of failure, owing to the attack of a disease which has been present there for many years, the question naturally arises as to what was the cause, and whether there is a possibility that others of the newer canes now coming into general cultiva-

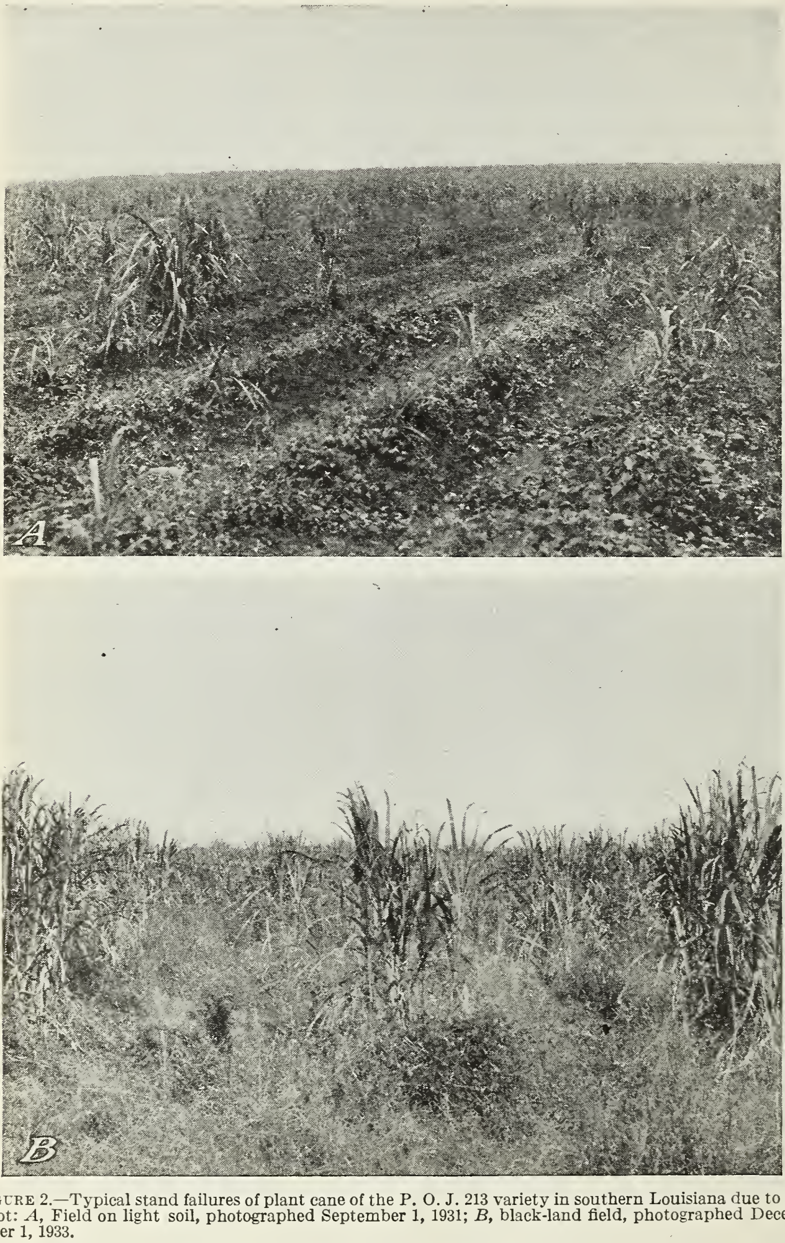

FIGURE 2.—Typical stand failures of plant cane of the P. O. J. 213 variety in southern Louisiana due to red rot: *A*, Field on light soil, photographed September 1, 1931; *B*, black-land field, photographed December 1, 1933.

tion may follow the same course, resulting in heavy monetary losses to the industry.

POSSIBLE CAUSES OF THE FAILURE OF P. O. J. 213

In seeking the cause of failure of P. O. J. 213, four possible explanations suggest themselves:

(1) An actual change in the inherent resistance of the variety, which would presume an en masse change in its genetic constitution and is therefore hardly to be considered.

(2) An increase in susceptibility as the result of long-continued subjection to unfavorable environmental conditions, resulting in nutritional or physiological disturbances. This seems improbable in view of the fact that cuttings of P. O. J. 213 from the muck lands of southern Florida, the sandy lands of Georgia and Mississippi, and the various soil types of the Louisiana sugar belt have all proved equally susceptible when artificially inoculated.

(3) The possibility that prior to 1930 the variety had not been subjected to conditions favorable to the development of red rot, so that its susceptibility had not been apparent. As early as 1927, however, a considerable acreage of P. O. J. 213 was planted on heavy soils, where red-rot injury to seed cane is more severe, and, considering the heavy borer infestation to which this variety has always been subject, lack of exposure to red-rot infection does not seem a plausible explanation for its escape from injury by the disease prior to 1930. The records show that P. O. J. 213 gave satisfactory stands and yields on both light and heavy soils from 1926 to 1929 (*5*, *6*, *17*), when weather conditions seem to have been as favorable for red-rot development as in the years subsequent to 1930. Edgerton (*11*) reported severe red-rot injury to D–74, Purple, and Crystalina in 1927, but stated that "the three released varieties of P. O. J. cane (36, 213, and 234) are not much affected by this disease."

(4) The development of a strain of the red-rot fungus more virulent on P. O. J. 213 than those present in the State prior to its introduction, or of a virulent one previously present which had not found conditions favorable for its development.

The possibility of the existence of strains of *Colletotrichum* of differing virulence was suggested by Edgerton several years ago (*10*), and later mentioned by him as very probable in the case of *C. falcatum* (*2*). It may be said here that while evidence of the existence of physiologic forms of *C. falcatum* has been obtained (*3*), it has not yet been possible definitely to explain the failure of P. O. J. 213 on the basis of the development of a virulent strain of the fungus.

It is with the above questions in mind that a study of the red-rot problem has been undertaken by the Division of Sugar Plant Investigations at its field station at Houma, La. The investigation is being carried out along the following principal lines: (1) A study of physiologic forms of *Colletotrichum falcatum*, the development of one or more of which might explain the failure of P. O. J. 213; (2) the relative susceptibility of the commercial varieties and promising new seedlings to red rot; and (3) determination of the fungi causing seed rotting and their importance. This circular summarizes the work on the last two phases of the problem.

RELATIVE SUSCEPTIBILITY OF SUGARCANE VARIETIES TO RED ROT

LABORATORY COMPARISONS

Since red rot is primarily a stalk-rotting disease, it presumably would be possible to study the relative resistance of sugarcane varieties to it by inoculating cuttings with the fungus under controlled conditions in the laboratory and observing the relative spread of the disease after a period of incubation, but it will later be shown that these observations must be supplemented by field study to get the true picture of relative varietal performance under plantation conditions. Many laboratory inoculations have been made, using the following technic: Cuttings free of moth borer and other apparent injuries were selected for uniformity as to size and maturity, washed, soaked in a solution of formaldehyde, 1 to 240, for 2 hours, and then allowed to dry. This sterilization has been effective except where infection through the root rings had progressed too far to be reached by surface treatment. Small holes were bored in alternate internodes of each cutting with an ordinary cork borer, and a bit of fruiting culture of *Colletotrichum* was inserted into the holes with a sterile scalpel or needle. The cuttings (at least 10 of each variety) were packed in steamed sawdust in a protected place, and after a period of incubation (usually 30 days) they were split lengthwise and the spread of the fungus was determined. Sawdust was used in preference to soil because of the ease of maintaining an almost constant temperature and the greater convenience in handling the cane when it was split.

For accurate determination of the spread of the fungus in studying physiologic forms, the length and width of the rotted area were measured as described elsewhere (*3*), but in comparing the commercial canes and promising seedlings, when usually not more than 10 or 12 varieties were being studied at once, visual examination was considered sufficient for classifying them into the following four groups of susceptibility: Resistant, moderately susceptible (might also be termed moderately resistant), susceptible, and very susceptible. It must be borne in mind that such a classification is one for convenience only, and that the differences are relative with no sharply defined limits between classes. For example, there is sometimes a question as to whether a cane should be considered moderately susceptible or susceptible, or, susceptible or very susceptible. Nevertheless, it has been found convenient to employ these four classes. Figure 3 shows typical results of one of the laboratory experiments to determine varietal reaction toward red rot.

COMPARATIVE SUSCEPTIBILITY OF VARIETIES BASED ON LABORATORY INOCULATIONS

Based only on inoculation of cuttings in the laboratory, the commercial varieties of both the sirup- and sugar-producing sections of the country and certain promising seedlings have been classified as follows: Very susceptible, Purple,[2] Ribbon, D–74, P. O. J. 213 and C. P. 807; susceptible, P. O. J. 36–M, P. O. J. 2725, Co. 290, Cayana, and C. P. 29/320; moderately susceptible, P. O. J. 36, P. O. J. 234, and C. P. 28/19; resistant, Co. 281, C. P. 28/11, and C. P. 29/291.

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[2] This variety is often referred to as Georgia Red in the sirup sections of the Southeastern States.

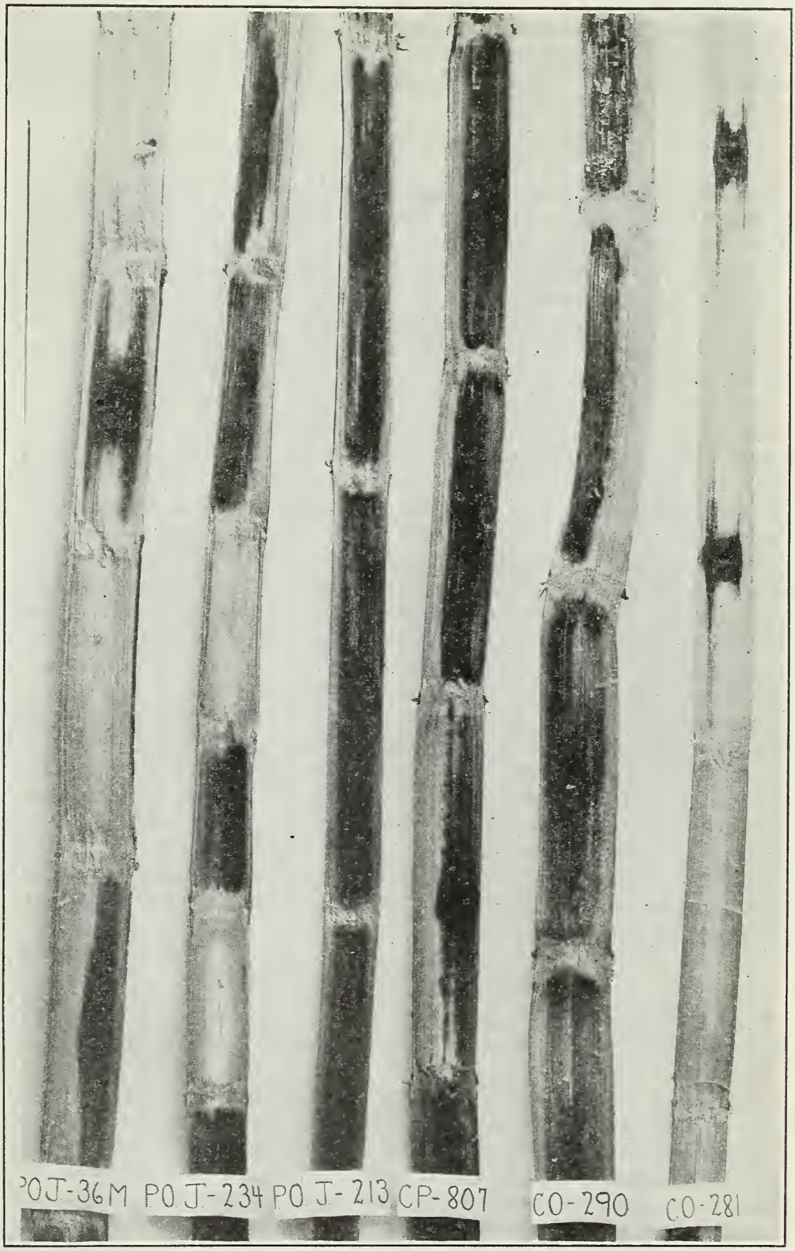

FIGURE 3.—Relative red-rot injury to six commercial varieties of sugarcane by the laboratory method of inoculation. The fungus was inserted into holes punched in the center of the internodes, the stalks stored in moist sawdust for 21 days at a constant temperature of 20° C. (68° F.), and split open for photographing. Co. 281 shows the greatest resistance, followed by P. O. J. 36-M and P. O. J. 234, while Co. 290 and C. P. 807 show almost as great susceptibility as P. O. J. 213. (Compare with fig. 4, where inoculation was made without wounding.)

With respect to the released varieties in Louisiana these ratings agree substantially with those given by Edgerton,[3] considering that he used five classes of susceptibility instead of four. Within the group of moderately susceptible canes, P. O. J. 36 is probably somewhat nearer to P. O. J. 36–M than the others, while P. O. J. 234 approaches the resistance of Co. 281.

FIELD RESISTANCE OF C. P. 807 AND Co. 290

The above classification of the released varieties has been borne out by their actual performance in the field with the exception of Co. 290, which so far has not shown any material seed rotting under usual plantation conditions and of C. P. 807, which did not show such injury until the rather severe winter of 1934–35. Evidently these varieties have some character which enables them to escape infection or to resist the spread of the disease in the field, since all laboratory inoculations which have been made over a period of more than 3 years indicate that they should be classed as susceptible.

As pointed out by Edgerton and Moreland (*13*), red-rot infection of seed cane takes place in two ways—through the tunnels of the moth borer and by penetration through the root rings. The latter type of infection commonly occurs when the seed cane lies dormant in the ground for a considerable period after planting and before growth begins, probably in large part from spores of the fungus which are lodged on the cuttings, but possibly also from those present in the soil. It seems possible, therefore, that an inherently susceptible variety which germinates quickly and is a vigorous root former might be able to resist this type of red-rot infection.

C. P. 807 and Co. 290 have a combination of two characters which distinguish them from the other susceptible varieties—quick germination and vigorous root development soon after planting. In variety tests in which most of the varieties mentioned above have been included in replicated plots, the Co. 290 and C. P. 807 plots can always be picked out at a distance because of the emergence of shoots in advance of the others and their very vigorous growth thereafter. An experiment was carried out with the view of determining whether in this character might lie the explanation for their usual resistance to red rot in the field.

ROOT RING INFECTION EXPERIMENTS

P. O. J. 213 and C. P. 807 were used for the test. Four-joint cuttings were surface sterilized by immersion in formaldehyde solution, 1 to 240, for 20 minutes at 52° C. (125.6° F.). After drying, each node of some of the cuttings was smeared with agar culture of *Colletotrichum*, and the remainder were left untreated. All were planted in steamed soil in flats and placed in the greenhouse for 35 days where the soil temperature was maintained at 20° to 25° (68° to 77° F.). The cuttings were then split and the nodes examined for infection.

Another set of cuttings was sterilized as above and placed in steamed sawdust for a few days until rootlets began to appear. The rootlets on half of the cuttings were cut off with a sterile knife, and on half of these culture of *Colletotrichum* was smeared, the remainder being left without inoculation. All were then planted in steamed soil as above and at the end of 35 days examined for red-rot infection. The results appear in table 1.

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[3] EDGERTON, C. W. DISEASE SUSCEPTIBILITY OF CANE VARIETIES. La. State Univ., Dept. Plant Path. Sugar Cane Rept. to Contact Com., June 9, 1933. [Mimeographed.]

Table 1.—*Comparative infection by the red-rot fungus through root rings of seed cuttings of C. P. 807 and P. O. J. 213 planted in the greenhouse*

Variety	Treatment	Total nodes	Nodes showing infection through root primordia or injured rootlets	
		Number	*Number*	*Percent*
C. P. 807	Unsprouted cuttings:			
	Inoculated	156	0	0
	Uninoculated control	75	0	0
	Sprouted cuttings:			
	Roots cut and inoculated	69	32	46
	Roots cut but not inoculated	52	0	0
	Roots not cut and not inoculated	62	0	0
P. O. J. 213	Unsprouted cuttings:			
	Inoculated	132	107	81
	Uninoculated control	54	0	0
	Sprouted cuttings:			
	Roots cut and inoculated	68	38	56
	Roots cut but not inoculated	40	0	0
	Roots not cut and not inoculated	31	1	3

It will be noted that when surface-sterilized but uninjured cuttings of C. P. 807 were inoculated with *Colletotrichum*, there was no evidence of infection through the root primordia in contrast to P. O. J. 213, 81 percent of the nodes of which showed such infection. Injury to the sprouting rootlets, caused by cutting and inoculating, produced infection in both C. P. 807 and P. O. J. 213. No cases of infection in the controls occurred except in one node of P. O. J. 213, which was doubtless due to natural infection which had progressed sufficiently prior to treatment to escape the effect of the surface sterilization. Figure 4 illustrates the resistance of C. P. 807 and the susceptibility of P. O. J. 213 toward infection through the uninjured root bands in this experiment.

These results indicate that C. P. 807 is able to resist infection through the root rings to a much greater extent than P. O. J. 213 and offer a possible explanation for the resistance to red rot shown by C. P. 807 in the field. Field observations extending over a considerable period tend to confirm the experimental results. Therefore, this type of resistance, which inhibits or prevents infection at the nodes, or by quick germination permits the plant to escape the disease, is evidently of considerable significance even though the same variety is unable to resist the spread of the fungus when entrance is gained through wounds.

FIELD-INOCULATION EXPERIMENTS

It appears from the foregoing that, while laboratory tests of susceptibility to red rot give a measure of the internal tissue resistance of a variety, they do not necessarily indicate the reaction of that variety to the disease under field conditions where other qualities may enable an inherently susceptible cane to escape infection. A series of tests was planted in the years 1930–33, therefore, with the view of determining the relative losses suffered by the commercial varieties and certain promising seedlings under conditions of severe infection in the field.

SEASONAL CONDITIONS

Weather conditions for the seasons of 1930–31 and 1931–32 have been described by Arceneaux and his associates (*7*, *8*). As they point out, temperatures during the winter and spring months of the 1930–31 season were abnormally low, and weather conditions were favorable for the development of red rot. The corresponding months of the season

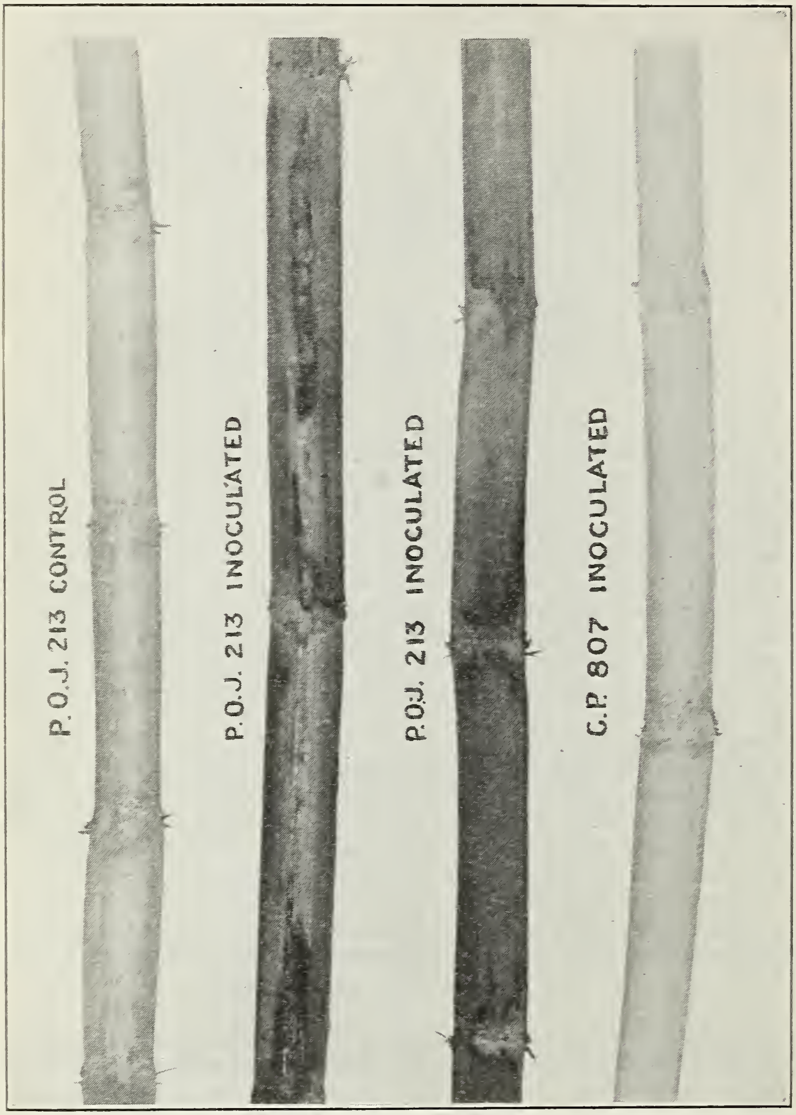

FIGURE 4.—Comparison of P. O. J. 213 with C. P. 807 for resistance of seed cuttings to infection by the red-rot fungus through the root rings, or root primordia. A culture of the fungus was smeared over the root bands, the cuttings were planted in steamed soil in the greenhouse, dug up after 4 weeks, and split open for examination. Eighty-one percent of the nodes of P. O. J. 213 showed infection through the root primordia with the fungus spreading through the internodes, while no infection occurred in the uninoculated controls or in the inoculated C. P. 807.

1931–32, on the other hand, were unusually favorable for the early germination and growth of cane, so that even the most susceptible varieties planted in the fall were able to germinate and establish independent root systems before the freezing weather of early March 1932, and thus escape serious red-rot injury. The effect of such unusual weather conditions was reflected in both experimental plots and plantation fields, where red-rot injury for that season was probably at the lowest point that can be expected with the present varieties.

The winter and spring months of the 1932–33 season were more similar to those of 1930–31, being characterized by unusually low temperatures and excessive rainfall. At three different times during the winter, freezing weather followed periods during which temperatures were sufficiently high to stimulate cane growth, resulting in a heavy drain on stored food reserves in both plant and stubble cane. This condition, aggravated by subsequent red-rot infection, caused widespread failure of stubble crops of P. O. J. 213 and P. O. J. 234, and of plant cane of P. O. J. 213, particularly where this variety had been planted on heavy soils.

METHODS OF PLANTING AND INOCULATING

The experiments were planted under conditions approaching plantation practice as nearly as possible. It was necessary to remove some of the sheaths from the seed cane in order to count the eyes, and badly bored cane was discarded. This precaution gave a seed supply for the experiments somewhat superior to that generally used on the plantations, but it was necessary in order to insure uniformity of seed for both check and inoculated plots.

Experiment 1, on light soil, and experiment 4, on heavy soil, were carried out with the idea of determining the effect of inoculation with red rot on germination and yields of the standard commercial varieties on soils representative of the two principal soil classes of the sugar belt of Louisiana, thus providing an opportunity to compare the results of field inoculations with those obtained in the laboratory. Single-row plots 16.5 feet in length were used, with the inoculated plots of each variety parallel and adjacent to the uninoculated ones. Eighty eyes were planted in each single-row plot in these and in the subsequent experiments described. This rate of planting gave satisfactory stands in the check plots, although it is slightly lower than is generally followed in commercial practice. The inoculations were made by inserting a bit of culture of the red-rot fungus in holes punched in alternate internodes of the cuttings with an ordinary cork borer, simulating injury by the sugarcane moth borer. It was considered possible that punching the holes in the seed pieces for the inoculated plots might in itself be sufficient injury to depress germination, but it was found in another series of experiments carried out with the same varieties at the same time and in the same manner that there was no significant difference in germination of cane so treated and that planted without boring.

Experiment 1, in which P. O. J. 36–M, P. O. J. 213, P. O. J. 234, Co. 281, and C. P. 807 were used, was planted on November 1, 1930, and harvested on November 27, 1931. Experiment 4, which included the same varieties with the addition of Co. 290, was planted on October 21, 1930, and harvested on November 25, 1931. Eight replications of each variety were planted, one of which was dug up in the spring for the purpose of examining the seed cane, leaving seven replications on which data were taken. From this examination it was determined that red rot had not reduced germination in the check plots, except in the case of P. O. J. 213. In this variety some natural infection had occurred through the nodes and probably accounted for the rather low germination figures in the checks. Spread of the disease was very much greater, however, in the inoculated seed cane.

The object of experiment 8 and the varieties used were the same as those in experiment 4. Instead of single-row plots, however, blocks of five 16½-foot rows of inoculated and five of control plots were used, with the inoculated plots end to end with the checks, thus eliminating the factor of competition between rows of unequal stand which were placed side by side in the former experiments. The blocks were replicated three times in checkerboard fashion as before. Yields were taken on the 3 middle rows of each block, each row being weighed separately and treated as a separate replication, thus making 9 replications of each variety.

Since greenhouse experiments had shown that resistance to red-rot infection through the root bands or through quick germination (p. 9) might be more important than internal tissue resistance under field conditions, experiment 12 was planted to test the effectiveness of the former qualities of the four varieties which were then planted commercially on mixed and heavy soils, namely, P. O. J. 234, C. P. 807, Co. 281, and Co. 290. In this test the inoculations were made by smearing some agar culture of the fungus over alternate nodes of the seed cuttings, without making any mechanical injuries. Otherwise the procedure followed was the same as that outlined for experiment 8, except that the blocks were replicated 4 times instead of 3, giving 12 replications for the test. The experiment was planted on November 9, 1932, and harvested on November 27, 1933.

For all of the experiments, records made during the growing season included counts of the total number of primary shoots (germination), stand count, number of millable stalks, and weight per plot at harvest time. Samples were analyzed for sucrose.

The results of the four experiments are summarized in table 2. The data in this table represent means of replicated pairs of inoculated and check plots of each variety. The detailed figures have been statistically analyzed according to Student's method as modified by Love (*16*), and odds of significance calculated. Odds of at least 30 : 1 have been taken as the minimum level of significance.

Table 2.—*Relative damage by red rot to several sugarcane varieties as indicated by reduction in germination and yields of plant cane in field-inoculation experiments, United States Sugar Plant Field Station, Houma, La., 1930–33*

Variety	Germination				Yield of cane per acre					Yield of sugar per acre				
	Inoculated	Check	Decrease (−) or increase (+) from inoculated seed cane	Approximate odds[2]	Inoculated	Check	Decrease (−) or increase (+) from inoculated seed cane		Approximate odds[2]	Inoculated	Check	Decrease (−) or increase (+) from inoculated seed cane		Approximate odds[2]
EXPERIMENT 1, ON LIGHT SOIL, 1930–31[1] (SEED CANE INOCULATED IN HOLES PUNCHED IN ALTERNATE INTERNODES)														
	Percent	*Percent*	*Percent*		*Tons*	*Tons*	*Tons*	*Percent*		*Pounds*	*Pounds*	*Pounds*	*Percent*	
P. O. J. 36–M	14.4	15.8	−8.9	2:1	16.60	18.07	−1.47	−8.1	2:1	1,863	2,224	−361	−16.2	5:1
P. O. J. 213	9.8	13.6	−27.9	3:1	10.65	18.83	−8.18	−43.4	[3]99:1	1,494	2,736	−1,242	−45.4	[3]99:1
P. O. J. 234	11.5	20.2	−43.1	[3]99:1	13.98	18.95	−4.97	−26.2	67:1	2,209	2,966	−757	−25.5	1:1
C. P. 807	22.2	26.8	−17.2	19:1	27.72	34.69	−6.97	−20.1	50:1	3,263	4,263	−1,000	−23.5	[3]99:1
Co. 281	20.8	24.0	−13.3	2:1	19.22	22.54	−3.32	−14.7	4:1	3,058	3,618	−560	−15.5	4:1
EXPERIMENT 4, ON HEAVY SOIL, 1930–31[4] (SEED CANE INOCULATED IN HOLES PUNCHED IN ALTERNATE INTERNODES)														
P. O. J. 36–M	9.8	21.0	−53.3	77:1	13.05	23.49	−10.44	−44.4	40:1	1,698	2,367	−669	−28.3	77:1
P. O. J. 213	6.8	16.7	−59.3	[3]99:1	10.80	20.16	−9.36	−46.4	[3]99:1	1,632	3,242	−1,610	−49.7	[3]99:1
P. O. J. 234	18.2	20.8	−12.5	6:1	17.51	20.60	−3.09	−15.0	41:1	2,978	3,486	−508	−14.6	6:1
C. P. 807	10.3	27.8	−62.9	[3]99:1	20.86	32.39	−11.53	−35.6	[3]99:1	2,791	4,551	−1,760	−38.7	[3]99:1
Co. 281	18.9	21.4	−11.7	3:1	17.89	22.19	−4.30	−19.4	12:1	2,843	3,446	−603	−17.5	3:1
Co. 290	29.1	31.7	−8.2	3:1	34.06	36.91	−2.85	−7.7	2:1	4,928	5,629	−701	−12.5	3:1
EXPERIMENT 8, ON HEAVY SOIL, 1931–32[5] (REPETITION OF EXPERIMENT 4)														
P. O. J. 36–M	11.4	19.6	−41.8	[3]99:1	16.07	19.95	−3.88	−19.4	58:1	2,247	3,386	−1,139	−33.6	[3]99:1
P. O. J. 213	17.9	22.1	−19.0	45:1	16.71	18.82	−2.11	−11.2	21:1	2,791	3,067	−276	−9.0	8:1
P. O. J. 234	24.4	28.4	−14.1	36:1	16.75	18.61	−1.86	−10.0	5:1	3,392	3,706	−314	−8.5	14:1
C. P. 807	37.1	42.1	−11.9	21:1	27.42	28.94	−1.52	−5.3	4:1	4,847	5,234	−387	−7.4	8:1
Co. 281	28.3	32.2	−12.1	68.1	21.52	21.54	−.02	−.09	1:1	3,810	4,008	−198	−4.9	3:1
Co. 290	34.6	35.1	−1.4	15:1	24.57	23.87	+.70	+.30	0	3,953	3,916	+37	+.1	0
EXPERIMENT 12, ON HEAVY SOIL, 1932–33[6] (SEED CANE INOCULATED BY SMEARING FUNGUS CULTURE ON UNINJURED ROOT RINGS)														
P. O. J. 234	21.6	25.3	−14.6	3:1	15.42	15.61	−0.19	−1.2	0	3,151	3,267	−116	−3.6	2:1
C. P. 807	25.7	34.9	−26.4	[3]99:1	21.36	24.95	−3.59	−14.4	[3]99:1	3,829	4,374	−545	−12.5	10:1
Co. 281	23.3	25.8	−9.7	3:1	18.33	18.28	+.05	+.03	0	3,271	3,368	−97	−2.9	1:1
Co. 290	26.0	22.3	+1.7	0	29.12	30.38	−1.26	−4.1	2:1	5,721	5,759	−38	−.7	1:1

[1] Data represent averages of 7 inoculated and 7 control plots of each variety.

[2] Determined by Student's method (*16*); odds of 30:1 considered significant.

[3] Odds greater than 99:1.

[4] Data represent averages of 7 inoculated and 7 control plots of each variety.

[5] Data represent averages of 9 inoculated and 9 control plots of each variety.

[6] Data represent averages of 12 inoculated and 12 control plots of each variety.

Experiment 13 was carried out for the purpose of comparing the resistance of Co. 281, Co. 290, C. P. 807, C. P. 28/19, and C. P. 29/320 to infection through the nodes, and to the spread of red rot after gaining entrance (i. e., through cork-borer holes). The procedure followed was the same as outlined for experiment 8, with a block of four rows of each variety being planted in which the inoculum was placed in cork-borer holes in the seed pieces, a second block with the inoculum smeared over the nodes, and a similar block of controls between. There were 16 replications of each type of inoculation and of controls of Co. 281 and Co. 290, and 12 replications of each for the other varieties. The experiment was planted in heavy soil on October 24, 1933, and the germination counts made on May 15, 1934. The germination figures are shown in table 3.

TABLE 3.—*Effect of red rot on germination of five sugarcane varieties by inoculating seed cuttings in cork-borer holes and on the nodes, United States Sugar Plant Field Station, Houma, La., 1934*

[Experiment 13 on heavy soil]

Variety	Germination on May 15						
		Inoculum placed in cork-borer holes			Inoculum smeared over nodes		
	Uninoculated	Actual	Decrease (−) or increase (+) from inoculated seed cane	Approximate odds	Actual	Decrease (−) or increase (+) from inoculated seed cane	Approximate odds
	Percent	*Percent*	*Percent*		*Percent*	*Percent*	
Co. 281	28.7	[1] 25.5	−11.2	26:1	[1] 30.1	+1.4	----------
Co. 290	32.1	25.6	−20.3	62:1	31.8	−0.9	2:1
C. P. 807	34.8	26.4	−24.1	43:1	32.1	−7.8	6:1
C. P. 28/19	27.7	25.3	−8.7	4:1	27.9	+.2	----------
C. P. 29/320	30.6	27.5	−10.1	4:1	29.3	−4.2	6:1

[1] Data are averages of 16 replications of inoculated and 16 control plots of Co. 281 and Co. 290, and of 12 replications of each for the other varieties.

EFFECT ON GERMINATION

In experiment 1, on light land, P. O. J. 234, with a reduction of 43.1 percent, was the only variety showing a significant reduction in germination. The average reduction of 27.9 percent for P. O. J. 213, which is known to be more susceptible than P. O. J. 234, is not statistically significant, a seeming discrepancy which is explained by the fact than many eyes of P. O. J. 213 produced primary shoots which were not able to survive and establish themselves as independent plants due to the rotting of the seed pieces from which they arose. The real effect of the disease on P. O. J. 213, and also on C. P. 807, was reflected in the yields of cane and sugar per acre, both of which were significantly lower in the inoculated than in the check plots.

It may be pointed out here that because of the nature of the disease, which may cause great decimation of stands, such large fluctuations are to be expected in the results obtained from the various replications of the inoculated plots and that yield reductions that would be significant in an ordinary yield test are not significant in an experiment of this kind. Even though an effort is made to have the inoculations uniform in all plots, such variation in the degree of infection and disease spread occurs in the various replications that large differences between inoculated and check plots are necessary to prove that they are not due to chance alone. For example, the yields of cane per acre for the seven inoculated plots of P. O. J. 213 in experiment 4 have a coefficient of variability of 40.3 percent, compared with 18.7 percent for the checks, while those of C. P. 807 have 28.2 percent for the inoculated and 9 percent for the check plots.

In experiment 4, on heavy soil, C. P. 807, P. O. J. 213, and P. O. J. 36–M showed significant reductions in germination, while the smaller reductions for the other varieties were not significant. These results from the field inoculations where the fungus was inserted into the stalk agree closely with those obtained from similar artificial inoculations in the laboratory in showing the relative resistance of the varieties.

In experiment 8, on heavy soil, significant germination reductions were obtained for P. O. J. 36–M, P. O. J. 213, P. O. J. 234, and Co. 281. It will be noted that, with the exception of 36–M, the results are similar for both the susceptible and resistant varieties. A probable explanation for this may be found in the abnormal weather conditions which prevailed throughout the winter of 1931–32, no freezing temperatures being recorded until March 9, 1932. The susceptible varieties which ordinarily would be injured by red rot during the normal period of dormancy in the fall and winter were able to begin growing soon after planting, and a majority of the primary shoots had established independent root systems before freezing weather occurred. This tended to put susceptible and resistant varieties on a more equal basis. The influence of weather conditions on red-rot injury was also reflected in plantation fields where the susceptible P. O. J. 213 suffered comparatively little from the disease during the 1931–32 season.

The ability of such a susceptible variety to escape serious injury when weather conditions permit the establishment of independent plants before the disease has an opportunity to develop, suggests the possibility of controlling red rot by late summer or early fall planting. If red rot were the only factor to be considered in making such early plantings, observations which have been made indicate that seed rotting could be largely controlled in this way. However, according to Arceneaux (*4*), summer planting of P. O. J. 213 has not proved successful.

Even if seed rotting of P. O. J. 213 could be controlled by summer planting or by fall planting under favorable conditions, there would still remain the question of losses to standing cane due to red rot, which are often serious in years of heavy borer infestation. This in itself is probably sufficient reason for abandoning the variety in the sugar-producing sections of Louisiana, or at least greatly curtailing its acreage in favor of varieties which are more resistant to red rot.

The germination figures for experiment 12, on heavy soil, where the fungus was merely smeared over the outside of the joints, indicate that the usual field resistance of C. P. 807 may be overcome if the infective agent is present during a prolonged period of dormancy, such as occurred during the winters of 1932–33 and 1934–35. Surface inoculation of the root rings reduced germination of this variety by 26.4 percent. Examination of the seed pieces in certain plots in the spring clearly showed the course of infection through the root bands and subsequent spread through the cuttings.

Greater resistance to this type of infection was shown by P. O. J. 234, for which a germination reduction of 14.6 percent was found; by Co. 281, with a reduction of 9.7 percent; and by Co. 290, for which germination was slightly higher in the inoculated than in the check plots.

In experiment 13 (table 3) inoculation of the seed cuttings through cork-borer holes caused a significant reduction in germination of 24.1 percent with C. P. 807 and 20.3 percent with Co. 290, both of which have been classed as susceptible to this type of inoculation in the laboratory tests. The smaller average reductions for the more resistant varieties were not significant. External inoculation of the nodes did not significantly reduce the germination of any of the varieties. The experiment indicates that the varieties are resistant to this type of infection when weather conditions are conducive to quick germination as they were in the fall and winter of 1933–34. In the case of Co. 281 this may be ascribed to the inherent resistance of the variety to any type of red-rot infection, while with the others, which are more susceptible than Co. 281, it is probably because of their ability to escape or ward off infection through quick and vigorous germination. However, the results of experiment 12, as well as certain field observations, show that C. P. 807 may suffer from such infection in a season unfavorable for early germination and growth.

EFFECT ON YIELDS OF CANE PER ACRE

In experiment 1, where inoculation was made in holes punched in alternate internodes of the seed cuttings, the comparative yields of cane per acre follow closely those for germination reduction, except in the case of P. O. J. 213. The germination reduction for this variety was not significant, whereas the reduction in yield of 8.18 tons per acre, or 43.4 percent, was greater than that for any other variety. As mentioned before, this resulted from the death of many primary shoots which were unable to establish themselves as independent plants because the seed pieces rotted following germination, so that the effect of the disease in this variety was evident in the yield rather than in germination. Significant yield reductions were also obtained for C. P. 807 and P. O. J. 234.

In experiment 4, which was a duplicate of experiment 1, but located on heavy soil, the greatest reductions in yield of cane per acre were obtained with C. P. 807, P. O. J. 36–M, and P. O. J. 213. P. O. J. 234 showed a small significant reduction, while no significance could be attached to the losses for Co. 281 and Co. 290. The ranking here based on yield reductions is in close accord with the laboratory determinations of the red-rot susceptibility of the different varieties, except in the case of Co. 290. The varieties found most susceptible in the laboratory inoculations, P. O. J. 213, C. P. 807, and P. O. J. 36–M, showed the greatest reductions in the field, while the more resistant P. O. J. 234 and Co. 281 showed smaller losses. Co. 290, which has proved susceptible in all laboratory inoculation tests, has consistently resisted infection and spread of red rot in the field experiments. No definite explanation of this can be offered.

Experiment 8, on heavy soil, cannot be considered representative in view of the abnormal weather conditions which prevailed during the winter of 1931–32. Little red-rot injury is to be expected under conditions favoring rapid growth of cane and early establishment of independent plants. The effect of such conditions was reflected in the experimental plots, as well as in plantation fields, where red-rot injury for that year was probably at about the lowest point that can be expected with the present varieties.

In experiment 12, on heavy soil, to test infection of uninjured cane, only C. P. 807 showed a significant reduction in cane yield, corresponding with the reduction in germination. The loss from inoculation was 3.59 tons per acre, or 14.4 percent. While this reduction is less than that obtained for this variety in the other experiments, it is particularly important since it was brought about entirely by infection of seed cane through the root bands and not through mechanical injuries.

The slight reductions in tonnage recorded for Co. 290 and P. O. J. 234 were not significant, while the yields of check and inoculated plots of Co. 281 were practically equal.

EFFECT ON SUCROSE CONTENT OF THE JUICE AND YIELD OF SUGAR PER ACRE

The yields of sugar per acre for experiment 1 (table 2) follow very closely those for cane per acre. Inoculation caused significant reductions for P. O. J. 213 and C. P. 807, while the losses recorded for the other varieties were not significant. In experiment 4, on heavy soil, significant losses were found for P. O. J. 213, P. O. J. 36–M, and C. P. 807.

The effect of inoculation of seed cane with *Colletotrichum falcatum* and *Melanconium sacchari* and the subsequent reduction in stand on the analysis of the juice are shown in table 4. It will be noted that for every variety showing a significantly reduced yield of cane, there was a corresponding, although slight, lowering of the sucrose content and purity of juice. In experiment 4, for example, the sucrose analysis of P. O. J. 213, for which the average yield reduction was 9.36 tons per acre (table 2), was 11.76 percent for the check plots compared with 11.16 percent for the inoculated ones, with corresponding purities of 79.73 and 78.32. C. P. 807, yield of which was reduced 11.53 tons per acre (table 2), showed 10.80 percent sucrose in the check and 10.31 percent in the inoculated plots, with corresponding purities of 76.76 and 75.48. In experiment 5, with *Melanconium sacchari*, a similar situation was noted.

This reduction in sucrose and purity may be ascribed to the gaps in the stand, the effects of which on maturity of cane have been discussed by Arceneaux and his associates (*7*). In all cases where a gappy stand resulted from the inoculations suckering was stimulated, thereby delaying maturity of the cane, lowering sucrose and purity, and bringing about a reduced yield of sugar per ton of cane.

TABLE 4.—*Effect of inoculation of seed cane with red rot (Colletotrichum falcatum) and the rind disease (Melanconium sacchari) fungi on quality of juice of the resulting plant-cane crop of several varieties of sugarcane, United States Sugar Plant Field Station, Houma, La., 1930–31*

EXPERIMENT 1, RED ROT IN LIGHT SOIL

Variety	Chemical analyses [1]						Calculated pounds of sugar per ton of cane		Decrease (−) or increase (+) from inoculated seed cane
	Inoculated			Check			Inoculated	Check	
	Brix	Sucrose	Purity	Brix	Sucrose	Purity			
		Percent			*Percent*		*Pounds*	*Pounds*	*Pounds*
P. O. J. 36–M	13.07	9.01	68.94	13.67	9.69	70.89	112.2	123.8	−11.6
P. O. J. 213	14.12	10.62	75.21	14.27	10.90	76.38	140.3	145.3	−5.0
P. O. J. 234	14.97	11.69	78.09	14.97	11.62	77.62	158.0	156.5	+1.5
C. P. 807	13.22	9.42	71.26	13.37	9.72	72.70	117.7	122.9	−5.2
Co. 281	15.21	11.81	77.65	15.32	11.91	77.74	159.1	160.5	−1.4
EXPERIMENT 4, RED ROT IN HEAVY SOIL									
P. O. J. 36–M	13.61	10.00	73.48	13.88	10.24	73.78	130.1	133.6	−3.5
P. O. J. 213	14.25	11.16	78.32	14.75	11.76	79.73	151.1	160.8	−9.7
P. O. J. 234	15.37	12.37	80.48	15.45	12.35	79.94	170.1	169.2	+.9
C. P. 807	13.66	10.31	75.48	14.07	10.80	76.76	133.8	140.5	−6.7
Co. 281	15.00	11.74	78.27	14.75	11.50	77.97	158.9	155.3	+3.6
Co. 290	14.37	10.52	73.21	14.68	10.95	74.59	144.7	152.5	−7.8
EXPERIMENT 5, RIND DISEASE IN HEAVY SOIL									
P. O. J. 36–M	13.72	10.09	73.54	13.88	10.24	73.78	131.4	133.6	−2.2
P. O. J. 213	13.12	9.37	71.42	14.27	10.90	76.38	119.6	145.3	−25.7
P. O. J. 234	15.81	12.82	81.09	15.45	12.35	79.94	177.0	169.2	+7.8
C. P. 807	13.64	10.13	74.27	14.07	10.80	76.76	130.1	141.6	−11.5
Co. 281	14.72	11.46	77.85	14.75	11.50	77.97	154.6	155.3	−.7
Co. 290	14.37	10.52	73.21	14.68	10.95	74.59	144.7	152.5	−7.8

[1] Averages of 3 20-stalk samples.

TEST AT CAIRO, GA.

In view of the very different conditions under which sugarcane is grown in Georgia and the demonstrated fact that the dominant form of the red-rot fungus present in the sirup-producing districts of the Southeastern States is different from the dominant Louisiana form (*3*), it seemed desirable to carry out a seed-rotting test in that section. An experiment was planted at Cairo, Ga., at the United States Sugar Plant Field Laboratory, in November 1931, using Cayana, the leading commercial variety of the district, P. O. J. 213, and C. P. 807, the cultivation of which has increased rapidly in recent years, and Co. 290, which has shown promise in that section. The inoculations were made in cork-borer holes, as in the Louisiana tests, using the strain of *Colletotrichum* dominant in Georgia, which had been isolated the previous winter from severely rotted banked Cayana seed cane. There were 12 replications of each variety planted in blocks, as described for experiment 8 in Louisiana. The results appear in table 5.

Cayana was the only variety on which the effect of inoculation was manifest. Although the reduction of 7.5 percent in germination for this variety was not statistically significant, there was a significant reduction in the yield of cane per acre of 2.6 tons. This is worthy of note, since the strain of the fungus used was obtained from Cayana.

The yields for the three other varieties used were practically the same in both check and inoculated plots.

Mention should be made of the fact that this test was conducted during the mild winter of 1931–32, when weather conditions were as unfavorable for the development of red rot in seed cane in the Southeastern States as they were in Louisiana. Red-rot injury to both banked and planted seed cane that season was negligible. Very different results might be obtained in a more normal season, for, as mentioned in the introduction, red rot is frequently the cause of considerable loss to seed cane in the sirup-producing sections of the South.

TABLE 5.—*Relative damage by red rot to several sugarcane varieties as indicated by reduction in germination and yields of plant cane in field-inoculation experiments, United States Sugar Plant Field Laboratory, Cairo, Ga., 1930–31*

Variety	Germination[1]				Yield of cane per acre[1]				
	Inoculated	Check	Decrease (−) or increase (+) from inoculated seed cane	Approximate odds[2]	Inoculated	Check	Decrease (−) or increase (+) from inoculated seed cane		Approximate odds[2]
	Percent	*Percent*	*Percent*		*Tons*	*Tons*	*Tons*	*Percent*	
Cayana	37	40	−7.5	14:1	25.38	27.98	−2.60	−9.29	[3] 99:1
C. P. 807	50	50	.0	0	32.85	31.50	+1.35	+4.29	0
Co. 290	44	42	+4.8	0	35.40	35.58	−.18	−.05	1:1
P. O. J. 213	37	38	−2.6	2:1	28.50	27.98	+.52	+1.86	0

[1] Data calculated from averages of 12 inoculated and 12 control plots of each variety.
[2] Determined by Student's method (*16*); odds of 30:1 considered significant.
[3] Odds greater than 99:1.

OTHER FUNGI INVOLVED IN SEED ROTTING

In addition to the experiments with *Colletotrichum falcatum* other fungi, which it was thought might be concerned in seed rotting, have been studied. The most important of these is *Melanconium sacchari*, the rind rot fungus, which is commonly found affecting cane stalks that have been injured by some other agent. It is a wound parasite, apparently unable to infect cane that has not been mechanically injured or attacked by some other disease, such as red rot.

A purple species of *Fusarium* is also common in seed cuttings as well as in the growing stalk following borer injury, particularly on P. O. J. 213. On seed cane it is most evident in poorly drained soils where the purple fruiting masses of the fungus are frequently found on the rind of the cuttings. A white species of *Fusarium* and a species of *Basisporium* have also been isolated from diseased seed cuttings.

The *Melanconium* and presumably the same two Fusaria were studied by Edgerton and Moreland (*13*), who found that inoculation with *Melanconium* caused only slight germination reduction of D–74 and Louisiana Purple. Their results indicated that the purple *Fusarium* was not important, while the white species might play some part in seed deterioration.

To test the relative susceptibility of the commercial varieties of cane to *Melanconium*, this fungus was used in a field test which was planted under identical conditions with those described for experiment 4 with *Colletotrichum.* The inoculations were made by placing pieces of culture of the fungus in cork-borer holes in the seed cuttings. The experiment was planted on October 21, 1930, and harvested on November 25, 1931.

From the results, which appear in table 6, it will be noted that significant reductions in germination resulting from inoculation were obtained with P. O. J. 213, P. O. J. 234, and C. P. 807, but not for the other varieties. Examination of the seed in some of the plots showed that the rotting was actually due to *Melanconium* and not to *Colletotrichum.*

TABLE 6.—*Relative damage by rind disease (Melanconium sacchari) to several sugarcane varieties as indicated by reduction in germination and yields of plant cane in field-inoculation experiments, United States Sugar Plant Field Station, Houma, La., 1930–31*

[Experiment 5 on heavy soil, 1930–31—averages of 7 inoculated and 7 check plots of each variety]

Variety	Germination				Yield of cane per acre				
	Inoculated	Check	Decrease (−) or increase (+) from inoculated seed cane	Approximate odds [1]	Inoculated	Check	Decrease (−) or increase (+) from inoculated seed cane		Approximate odds [1]
	Percent	*Percent*	*Percent*		*Tons*	*Tons*	*Tons*	*Percent*	
P. O. J. 36–M	14. 1	20. 1	−29. 9	20:1	12. 36	21. 01	−8. 65	−41. 2	[2] 99:1
P. O. J. 213	4. 9	12. 4	−60. 5	48:1	10. 30	20. 40	−10. 10	−49. 5	[2] 99:1
P. O. J. 234	18. 1	24. 0	−24. 6	[2] 99:1	18. 13	19. 99	−1. 86	−9. 3	4:1
C. P. 807	20. 5	29. 9	−31. 4	[2] 99:1	24. 10	30. 49	−6. 39	−21. 0	[2] 99:1
Co. 281	18. 5	21. 4	−13. 6	[2] 99:1	18. 74	20. 40	−1. 66	−8. 1	8:1
Co. 290	33. 7	32. 6	+3. 4	--------	34. 81	31. 93	+2. 88	+9. 0	--------
					Yield of sugar per acre				
					Pounds	*Pounds*	*Pounds*		
P. O. J. 36–M					1, 624	2, 807	−1, 183	−42. 1	[2] 99:1
P. O. J. 213					1, 232	2, 965	−1, 733	−58. 4	[2] 99:1
P. O. J. 234					3, 210	3, 382	−172	−5. 1	10:1
C. P. 807					3, 072	4, 230	−1, 158	−27. 4	[2] 99:1
Co. 281					2, 897	3, 167	−270	−8. 5	11:1
Co. 290					5, 350	5, 161	+189	+3. 7	--------

[1] Determined by Student's method (*16*); odds of 30:1 considered significant.
[2] Odds greater than 99:1.

Reductions in yields of cane per acre were significant for P. O. J. 213, P. O. J. 36–M, and C. P. 807, while the smaller losses for the other varieties were not significant. Corresponding reductions in pounds of sugar per acre were obtained for the three varieties named. The average juice analyses of cane from inoculated and control plots and calculated sugar per ton of cane in this experiment are presented in table 4 in comparison with similar data from the red-rot experiments.

It appears from these figures that of the varieties used in the experiment, those that are most susceptible to *Colletotrichum* are also the most susceptible to *Melanconium* under field conditions, and indicate that the latter organism may be a factor in seed rotting following red-rot or borer injury. Judging from field observations, it cannot be looked upon as an active parasite but rather as a secondary invader which may complete destruction of seed cane initiated by some other agency. It has not been observed infecting cane through the root rings.

In one inoculation test with the purple *Fusarium* on heavy soil, using the same five varieties as with *Melanconium*, germination was reduced only in the case of P. O. J. 213, being 5.8 percent in the inoculated and 9.9 in the control plots. This reduction cannot be definitely ascribed to the *Fusarium*, however, since on examination it was found that red rot was also present. The few inoculations made in the laboratory with this organism have not shown it to be more than weakly pathogenic.

A similar field test was planted with *Basisporium*, but none of the varieties showed a significant reduction in germination. In laboratory inoculations this organism has not proved to be pathogenic toward any of the varieties. A few inoculations with the white *Fusarium* have resulted similarly.

TABLE 7.—*Comparative germination of sugarcane varieties on mixed to heavy soils at Houma, La., 1931–34*

Variety	1931[1]		1932[1]		1932[2]		1933[1]		1934[1]		Average germination
	Plots	Germination	Plots	Germination	Plots	Germination	Plots	Germination	Plots	Germination	
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Percent*
P. O. J. 36–M	23	20. 1	15	19. 6	12	16. 4					18. 7
P. O. J. 213	23	15. 2	15	22. 1	12	15. 4					17. 6
P. O. J. 234	24	24. 5	19	28. 4	12	26. 6	12	25. 3			26. 2
Co. 281	24	22. 6	15	32. 2	12	26. 6	12	25. 8	16	28. 7	27. 2
Co. 290	17	29. 6	12	35. 1			12	22. 3	16	32. 1	29. 8
C. P. 807	32	28. 9	15	42. 1	12	38. 7	12	34. 9	12	34. 8	35. 9
C. P. 28/19									12	27. 7	27. 7
C. P. 29/320									12	30. 6	30. 6

[1] Experiments conducted at the U. S. Sugar Plant Field Station, Houma, La.
[2] Experiments conducted on Crescent Farm Plantation, near Houma, La.

RELATIVE GERMINATION OF SUGARCANE VARIETIES

When the P. O. J. canes replaced Purple, Ribbon, and D–74 in Louisiana several years ago, it was generally observed that they gave a much more satisfactory germination than the old varieties, and now that they in turn are being superseded by more desirable canes it is of interest to examine the comparative germination figures which have been obtained in experiments extending over a period of several years. In table 7 are shown the average germination percentages from the uninoculated check plots of the experiments already discussed, together with those of several others carried out at the same time and in the same manner, but not reported in this circular.

These figures reveal the very low germination that is obtained with sugarcane in Louisiana, only about one-third of the apparently sound eyes of even the most vigorous varieties producing plants. P. O. J. 213 and P. O. J. 36–M showed the lowest germination of any of the varieties; P. O. J. 234 and Co. 281 were intermediate; while the highest comparable averages were shown by C. P. 807 and Co. 290. With the exception of the tests in 1933, in which Co. 290 gave the rather low figure of 22.3 percent, this variety has shown germination comparable to that of C. P. 807, and figures which have been obtained from plantation plantings of these two varieties indicate that they may be expected to give about the same germination. Germination counts of the other varieties which have been made in plantation fields have given results similar to those above. A more extended study of germination under plantation field conditions is now in progress.

The failure of from two-thirds to three-fourths of the apparently sound eyes to germinate necessitates the planting of a considerably larger quantity of cane than would be required if a higher germination percentage were realized. Unfortunately, much of the low germination is due to causes beyond the control of the planter, but certain agricultural practices that can be controlled also exert an influence.

It should be borne in mind that the germination figures given have been based on counts of young plants that have appeared by about the first of May, whereas some eyes remain sound and dormant for a longer period and germination continues throughout the summer. The germination counts have been made around the first of May because of the difficulty of distinguishing between primary and secondary shoots after suckering begins. While the figures thus obtained may not represent the actual maximum germination, they probably do show the number of primary or mother shoots which appear early enough to reach maturity.

Among the factors influencing germination over which the planter has little or no control may be mentioned soil moisture, soil temperature, injury to the eyes by the larvae of the sugarcane weevil after planting, and, to some degree, soil type. The last-mentioned may be controlled to the extent of planting the more vigorous varieties on the heaviest lands, but on many plantations the relative proportion of heavy and light soils is such that there is little choice as to their use.

The planter may, however, exercise a considerable degree of control over the depth of planting or amount of soil placed on the seed cane at planting time, the degree of borer injury to seed cane by the choice of fields for seed showing the lightest infestation, the treatment to which the cane is subjected in cutting and planting, and by the use of mosaic-free seed of varieties particularly subject to injury by this disease.

Excessively deep covering of seed cane at planting time is responsible for a great deal of avoidable germination reduction. The rate of germination is considerably retarded when cane is covered too deeply, and the consequent prolonged dormancy of the seed cuttings often enhances red-rot injury to susceptible varieties. This fact is brought forcibly to one's attention every spring in examining gaps in plant cane stands by the finding of seed pieces covered to a depth of 6 to 8 inches, and in extreme cases, 10 to 12 inches, after the cane has been off-barred and hoed. It is extremely difficult, of course, to plant large acreages of cane and have an even coverage throughout, but covering to a depth in excess of 6 inches certainly can be avoided. Four inches is probably an adequate depth for planting in most cases, but even with 6 inches of soil on the cane at planting time in the fall, the washing and packing effect of the winter rains will reduce this depth considerably by spring. In the spring when gaps are noted in fall-planted cane, it would be advisable to determine whether they may be due to too deep planting, and, if so, to remove the excessive soil with hoes.

Mention need scarcely be made of the desirability of handling seed cane in such a manner as to avoid injuring the eyes by the cutting knives and by the process of loading and unloading from the wagons. It is a general plantation practice to cut or whack the seed pieces of crooked canes, but this is frequently not done with straight varieties such as Co. 281, Co. 290, and P. O. J. 36–M. Field observations indicate that whacking the longer canes into pieces about 18 to 24 inches in length stimulates germination of the central eyes and is to be recommended for that reason, as well as to insure better placement and covering in the furrow.

The value of using borer-free seed cane to avoid germination losses has been pointed out by Holloway and others (*15*) and by Hinds and his associates (*14*). While it will usually be impossible to obtain seed cane absolutely free of borer injury, a survey of possible sources of seed supply will usually show some fields to be less infested than others. Even though the eyes themselves may not be bored, the destruction or inversion of food reserves in the bored joints will often prevent the germination of the eyes on such joints. Bored cane is also much more subject to red-rot attack than sound cane.

Summers and Rands (unpublished report) call attention to the germination reduction which may be expected from the planting of mosaic seed of Co. 281, and with its establishment as one of the major varieties in Louisiana, the importance of selecting healthy seed cane should be emphasized. Such procedure is also highly desirable with the recently released varieties, Co. 290, C. P. 28/11, and C. P. 28/19, all of which have shown mosaic, but the effects of which on germination and yields have not yet been fully determined. As a general practice, however, the preservation of mosaic-free seed supplies is to be recommended wherever possible.

DISCUSSION

On the whole, the results of the field experiments are in substantial agreement with those obtained in the laboratory with regard to the relative susceptibility of the varieties and their actual field performance, except for C. P. 807 and Co. 290. The experimental results indicate greater susceptibility and greater field injury from artificial inoculation than has generally occurred in commercial plantings. In the case of C. P. 807 many instances of red-rot injury have been observed which, in the light of the experimental results, indicate that susceptibility to red rot is a great potential weakness of that variety. In the spring of 1932 a field of about 3 acres of fall-planted C. P. 807 on one plantation came up to an indifferent stand. On examination it was found that the cane had been covered to a depth of from 8 to 10 inches, thereby preventing or delaying growth activity. Splitting the seed pieces dug from the gaps revealed extensive red-rot injury, with the infection clearly traceable to nodal entrance. The cane was practically free of borer injury. This observation checks with the experimental field tests in which nodal infection reduced germination when the cane remained dormant in the ground for a considerable period.

In the spring of 1933 three fields of C. P. 807 second stubble on as many plantations, which came up to a poor stand, were found to be rather severely affected by red rot. In each instance the cane had been cut in early October the preceding fall, and during the winter had produced considerable growth at least three times, only to be killed by freezing weather. While the drain on stored-food reserves in the rhizomes which resulted from this alternate growth activity and freezing, together with early cutting, appears to have been the primary cause of the stand failure, the inherent susceptibility of the variety to red rot must be considered an important contributing factor.

In the spring of 1935 stand reductions of both plant cane and stubble crops of C. P. 807, particularly second and third stubbles, were general on heavy soils in Louisiana. The low temperatures which prevailed during much of the winter of 1934-35 prevented the usual early germination and growth of this variety, with the result that severe red-rot injury occurred. While the great vigor of the variety enabled it to partially recover from this injury in some instances, the stand reductions which occurred were sufficiently great to emphasize the hazards accompanying the growing of such a susceptible variety.

Red-rot loss to standing cane of C. P. 807 is not great. Hinds, Osterberger, and Dugas (*14*) found a much smaller incidence of red rot in bored C. P. 807 standing cane than in P. O. J. 213, which is borne out by the writer's field observations. It also shows a considerably smaller incidence of borer injury than P. O. J. 213 and is, therefore, less subject to red-rot infection. This is an important factor in reducing injury to both standing and seed cane. While there are no experimental data on the subject, it appears from observation that C. P. 807 and Co. 290, and perhaps other varieties as well, are more resistant to red rot when actively growing than when in a dormant condition. Such a possibility in cane varieties has been suggested by Edgerton and Moreland (*13*).

As previously mentioned, P. O. J. 213 has ceased to be a major variety in the sugar-producing sections of Louisiana because of severe red-rot injury to seed cane, standing cane, and stubbles. In some instances good stands are still being obtained on limited acreages, with satisfactory yields of cane and sugar being realized. However, such results are possible only under the most favorable conditions of soil type and tilth, weather, seed supply, and planting, and where these conditions cannot be depended upon to be favorable, the hazards of failure with P. O. J. 213 are so great that its continued culture cannot be recommended.

SUMMARY

Red rot has evidently been a more or less constant source of loss to the sugarcane industry of the United States, particularly in Louisiana, where it is responsible for reduced stands of both plant and stubble crops and poor quality of juice of susceptible varieties. Since 1930 it has become a serious problem in that State because of the widespread failure of P. O. J. 213 which previously was considered resistant to the disease. Although several possible explanations for the failure are suggested, it has not yet been possible to definitely explain it on the basis of any of them.

Based on laboratory inoculations, the commercial varieties of sugarcane and certain promising seedlings have been classified as follows with respect to their susceptibility to red rot: Very susceptible, Purple, Ribbon, D–74, C. P. 807, and P. O. J. 213; susceptible, Co. 290, P. O. J. 36–M, C. P. 29/320, and Cayana; moderately susceptible (or moderately resistant), P. O. J. 36, P. O. J. 234, and C. P. 28/19; resistant, Co. 281, C. P. 28/11, and C. P. 29/291.

Under field conditions C. P. 807 and Co. 290 have shown greater resistance than is indicated by the laboratory tests, which it is believed is due at least in part to their rapid germination and vigorous root development, thus preventing nodal infection by red rot. Resistance to or escape from infection through the root rings under usulal field conditions in Louisiana may, therefore, permit commercial utiization of valuable varieties like these, especially Co. 290, that are inherently susceptible to the disease. It is suggested that these varieties may be also more resistant when actively growing than in the dormant state.

In field inoculation experiments where a culture of the fungus was inserted into holes punched into alternate internodes of the stalk, P. O. J. 213, P. O. J. 36–M, and C. P. 807 showed, in general, the greatest reductions in germination and in yields of cane and sugar per acre. Smaller reductions found for P. O. J. 234, Co. 281, and Co. 290 were not significant. Higher temperatures for germination and possibly greater resistance of actively functioning tissues may account for the slight damage to Co. 290 which was susceptible in the laboratory experiments.

Decimation of stands due to red rot caused reduction in sucrose content and purity of the cane juice. This is explained by the more abundant tillering induced by the gappy stands, resulting in later maturity of the cane.

In a single test at Cairo, Ga., Cayana was the only one of four varieties showing a significant reduction in yield due to inoculation. The strain of the red-rot fungus used had been isolated from severely rotted Cayana banked cane.

The rind disease fungus (*Melanconium sacchari*) caused significant reductions in germination of C. P. 807, P. O. J. 213, P. O. J. 36–M, and P. O. J. 234, with corresponding losses in yields of cane and sugar per acre of all these varieties except P. O. J. 234. No significant reductions were obtained for Co. 281 or Co. 290. *Melanconium* is considered of secondary importance in seed rotting.

The presence of two species of *Fusarium* and one of *Basisporium* in rotting seed cane were noted, but none of these organisms is believed to be of much importance.

LITERATURE CITED

(1) Anonymous.
1930. department of plant pathology report. Sugar Bull. 9 (13, Apr. 1): 9–10.
(2) ———
1930. red rot investigations. Sugar Bull. 9 (16, June 1): 9.
(3) Abbott, E. V.
1933. physiologic forms of colletotrichum falcatum went. (Phytopathological note) Phytopathology 23: 557–559.
(4) Arceneaux, G.
1933. summary of date-of-planting tests. Sugar Bull. 11 (23): 1–3.
(5) ——— and Gibbens, R. T.
1931. variety tests of sugarcanes in louisiana during the crop year 1928–29. U. S. Dept. Agr. Circ. 162, 24 pp.
(6) ——— and Stevens, F. D.
1929. variety tests of sugarcanes in louisiana during the crop year 1927–28. U. S. Dept. Agr. Circ. 88, 16 pp., illus.
(7) ——— Stokes, I. E., and Bisland, R. B.
1932. variety tests of sugarcanes in louisiana during the crop year 1930–31. U. S. Dept. Agr. Circ. 242, 27 pp.
(8) ——— Stokes, I. E., Bisland, R. B., and Krumbhaar, C. C.
1933. variety tests of sugarcanes in louisiana during the crop year 1931–32. U. S. Dept. Agr. Circ. 298, 31 pp.
(9) Edgerton, C. W.
1910. colletotrichum falcatum in the united states. Science (n. s.) 31: 717–718.
(10) ———
1911. the red rot of sugar cane. a report of progress. La. Agr. Expt. Sta. Bull. 133, 22 pp., illus.
(11) ———
1928. red rot, root rot and soil types. Sugar Bull. 6 (10, Feb. 15): 8.
(12) ———
1928. disease resistance of p. o. j. 213 cane. Sugar Bull. 7 (4): 2, 5.
(13) ——— and Moreland, C. C.
1920. effect of fungi on the germination of sugar cane. La. Agr. Expt. Sta. Bull. 169, 40 pp., illus.
(14) Hinds, W. E., Osterberger, B. A., and Dugas, A. L.
1933. review of six seasons work in louisiana in controlling the sugar cane moth borer by field colonizations of its egg parasite, trichogramma minutum riley. La. Agr. Expt. Sta. Bull. 235, 36 pp., illus.
(15) Holloway, T. E., Haley, W. E., Loftin, U. C., and Heinrich, C.
1928. the sugar-cane moth borer in the united states. U. S. Dept. Agr. Tech. Bull. 41, 77 pp., illus.
(16) Love, H. H.
1924. a modification of student's table for use in interpreting paired experiments. Jour. Amer. Soc. Agron. 16: 68–73.
(17) Rands, R. D., and Sherwood, S. F.
1927. yield tests of disease-resistant sugar canes in louisiana. U. S. Dept. Agr. Dept. Circ. 418, 20 pp., illus.

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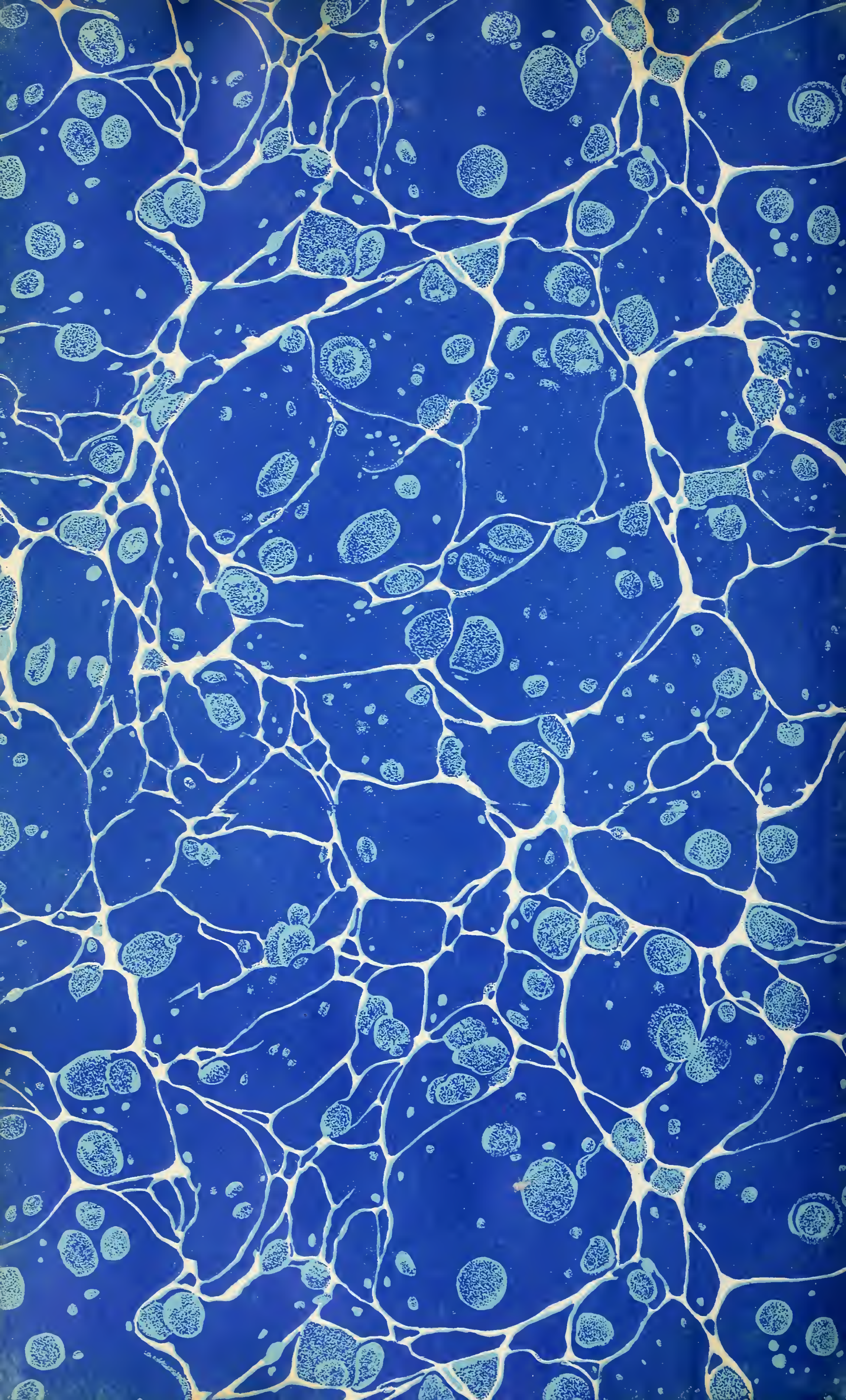

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